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(56) Documents cited
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(54) **Multi-wavelength ground scanner**

(57) Equipment for use on board an aircraft to survey the ground beneath especially for carrying out an 'earth resources' survey, comprises an infra-red radiation sensitive line scanner with a detector (13) arranged to receive radiation from the ground *via* an opto-mechanical reflective scanning rotor so that, in effect, the detector scans the ground along lines transverse to the direction of aircraft movement, and a carrier (17) which supports a series of infra-red filter elements having different radiation wavelength pass-bands and which is rotated, in synchronism with the scanner rotor, so that respective ones of the filter elements are moved into the radiation path as the respective successive scan lines are executed. A filter element position encoder is used to provide identifying signals for the successive scan lines so that the portions of the resultant video output signal associated with any particular filter element can be discriminated.

Fig. 1.

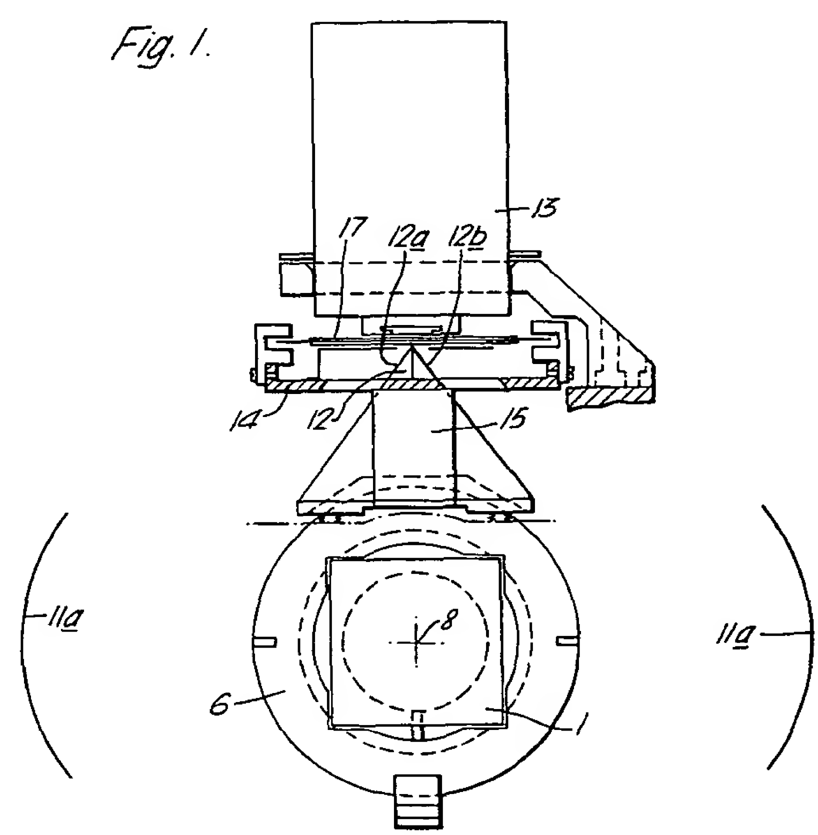


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Fig. 1.

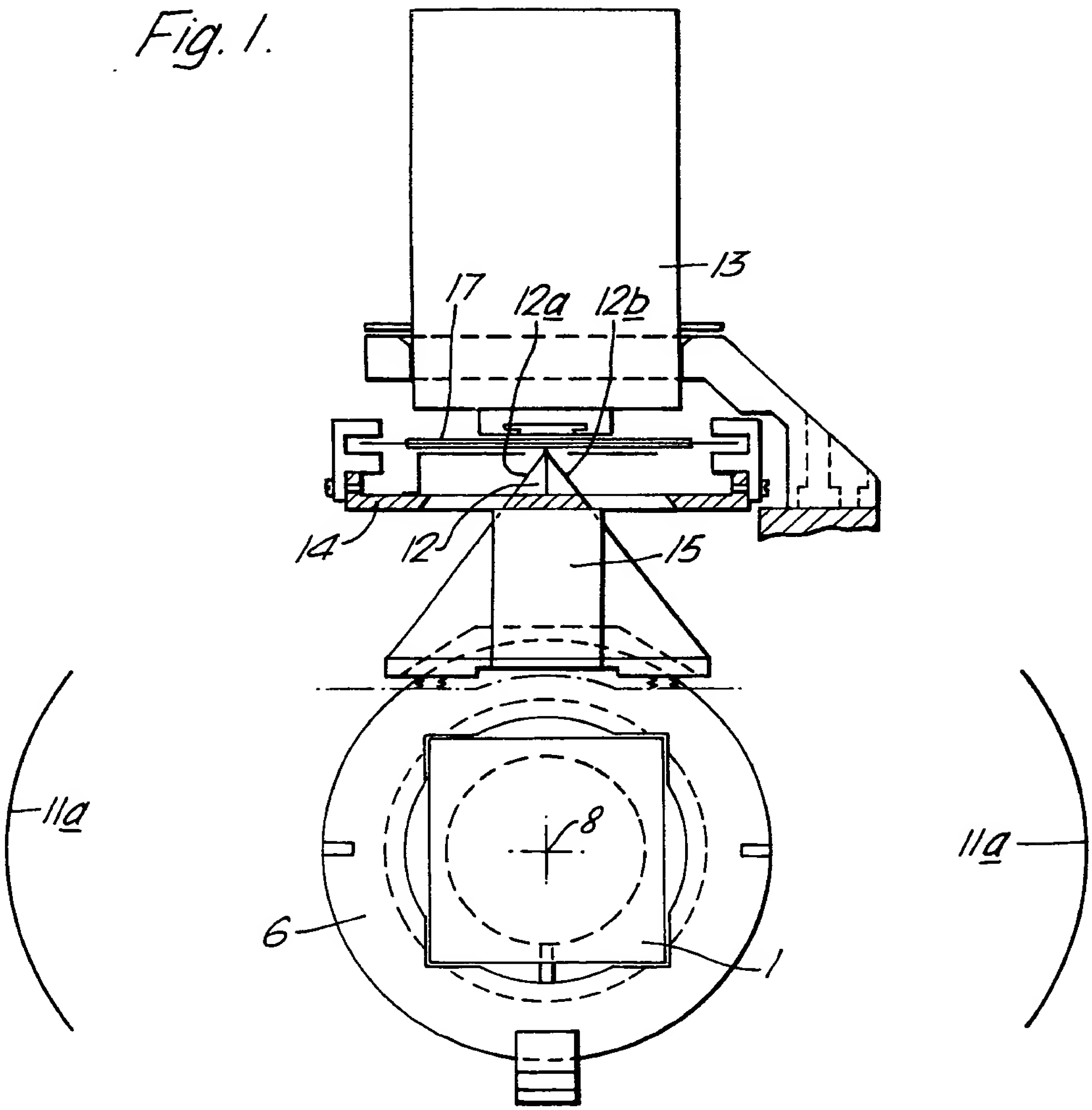
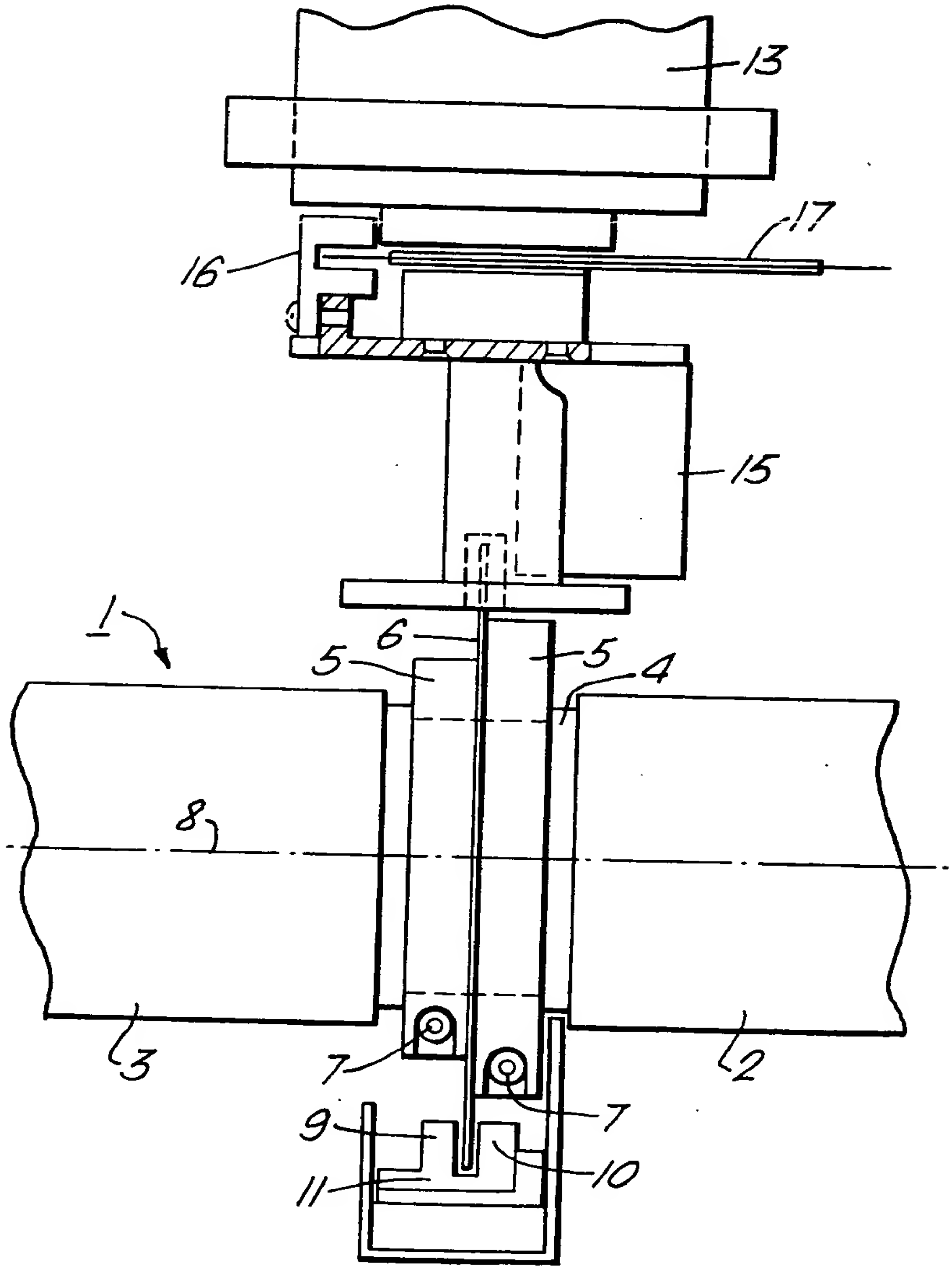
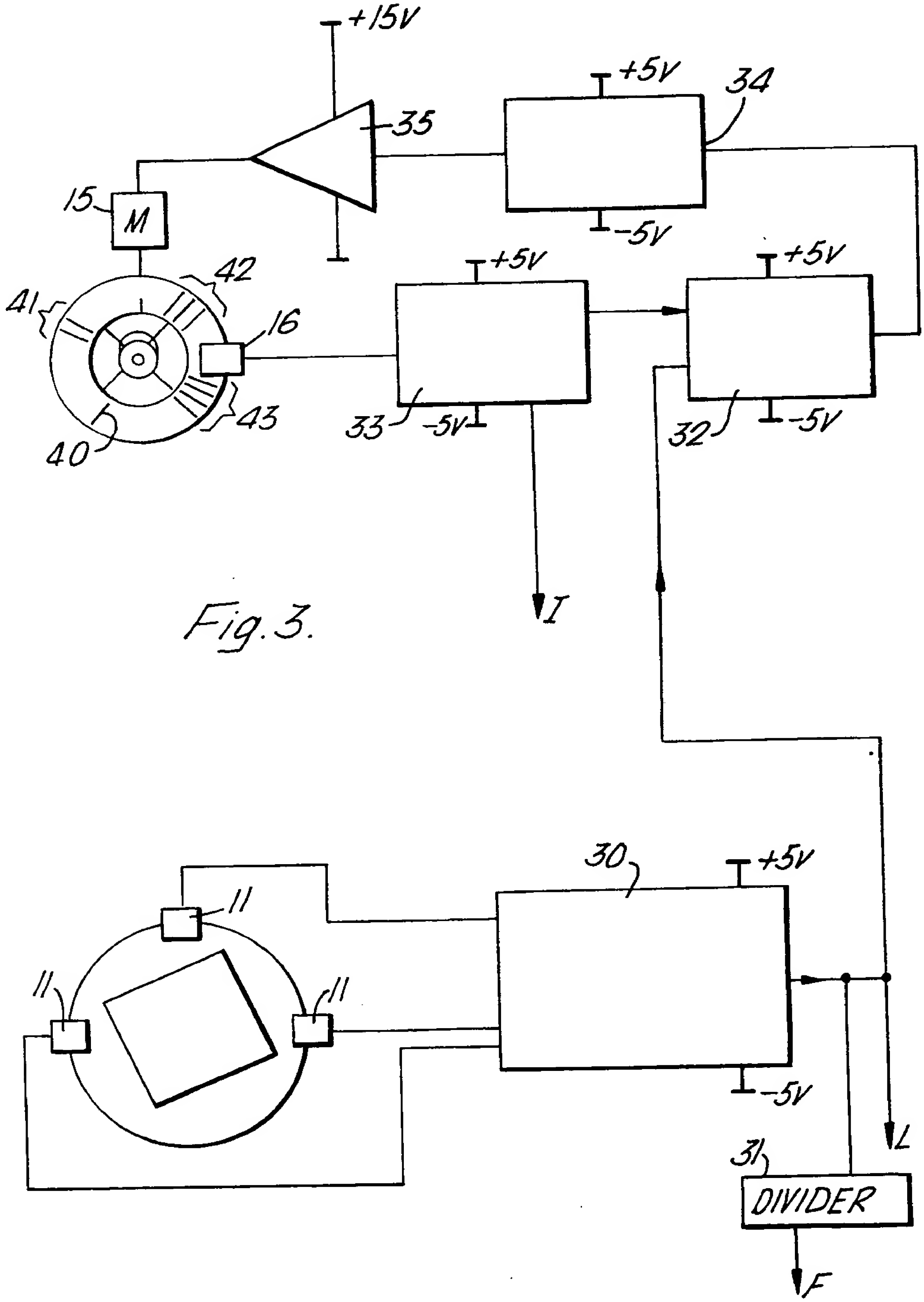


Fig. 2.





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+5V
34
35
15
M
-5V
42
+5V
+5V
41
16
33
-5V
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43
40
32
I
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+5V
11
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11
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L
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Fig. 3.

SPECIFICATION

**Ground surveillance**

This invention relates to apparatus for scanning a scene with a view to displaying or recording an image thereof.

Line scanning equipment for use on board an aircraft is known. It may comprise an opto-mechanical scanning device—a mirror-faced polygonal rotor for example which receives infra-red radiation from the ground beneath the aircraft and directs it *via* a collecting mirror system to an infra-red detector. Operation of the scanning device is such that the equipment scans the ground along lines transverse to the aircraft flight direction and thereby builds-up a continually progressing t.v. picture of the ground scene.

In order to provide an 'earth resources' survey of the ground terrain beneath an aircraft, it is desirable to look at the radiation from that terrain in each of several different infra-red wavelength bands—this allows the recognition of different rock formations having different thermal signatures.

It has been proposed that this be done using several different line scanners each responsive to a different waveband. It would be expensive however and also it may be difficult to properly 'integrate' the pictures from the different linescanners.

According to this invention, there is provided ground survey equipment comprising an optical radiation detector and scanner means for causing the detector to produce a video signal representative of a series of line scans over a ground scene, and further including filter carrier means supporting a plurality of filter members passing respective different optical radiation wavelength bands and means for causing the filter members to be moved in sequence into the path of radiation received by the detector.

For a better understanding of the invention, reference will be made by way of example to the accompanying drawings, in which:—

figures 1 and 2 are respective diagrammatic views of a line scanner, and

figure 3 is a simplified circuit diagram of the scanner.

The line scanner of figures 1 and 2 includes a scanning rotor 1 which is rotatable by an electrical motor (not shown) and which comprises two square section prismatic portions 2 and 3 at respective sides of a central portion 4 where there is mounted, by means of split clamp bosses 5, an encoder disc 6. By loosening the clamp screws 7 in bosses 5, the relative positions of the disc 6 and rotor portions 2 and 3 around the rotor axis 8 may be adjusted. The periphery of disc 6 has a series of holes in it and it moves between two parts 9 and 10 of an electro-optical sender/receiver device 11, the two parts 9 and 10 containing an optical sender and an optical receiver respectively whereby, as the holes in disc 6 move in and out of registry with the light path between the sender and receiver, electrical signals indicative of the position of the disc, and hence also of the rotor, are produced.

The faces of each rotor portion 2 and 3 are reflective. At respective sides of the rotor, and spaced therefrom, there are two curved collector mirrors 11*a* and, above the rotor, is a 'ridge mirror' 12, *i.e.* a triangular prismatic member of which the two surfaces 12*a* and 12*b* are reflective. The scanner is mounted in an aircraft (not shown) so that the axis 8 is generally parallel to the direction of flight and so that optical radiation from the ground beneath the aircraft can be received at the rotor. This radiation is reflected by the rotor portions 2 and 3 and, *via* the mirrors 11 and 12, enters a detector 13 including one or more radiation sensitive elements and a focussing lens system (not shown). The detector produces electrical signals representative of the radiation received by it.

The ridge mirror 12 is supported by a mounting plate 14 which also supports an electrical motor 15 and an opto-electrical sender/receiver device 16 similar to the device 11. The output shaft of the motor 15 extends adjacent one end of the ridge mirror 12, *i.e.* it is displaced from the optical axis of the optical detector 13. To the shaft is fixed a filter/encoder disc assembly 17 such that the disc is rotated by the motor and such that during such rotation, the outer periphery of the disc, with a series of holes therein, moves between the sender/receiver pair of the device 16 while a portion nearer the centre of the disc lies between the ridge mirror 12 and the entry to the radiation detector 13. Within this part of the disc 17, there are four apertures equi-spaced around the disc centre and containing respective optical filters transparent to respective different radiation pass-bands.

The radiation which enters the detector 13 arrives at the aircraft from within a particular subtended aperture angle which angle is dependent upon the particular design of the scanner and of which the central axis moves as the rotor 1 rotates. Thus, at any instant, the scanner is 'looking' at some relatively small area or patch on the ground, which patch moves transversely usually starting from a position to one side of the aircraft, then across through directly underneath the aircraft and then out toward the other side thereof. As the scanning rotor 1 continues to rotate, this transverse movement of the observed area is repeated giving, overall, a transverse line scan, the scan lines successively advancing along the ground with movement of the aircraft itself. For a given scanner and speed of scanning rotor rotation the size of the observed patch and hence the width of each scan line is dependent upon the height of the aircraft while the distance between each two adjacent lines is dependent upon the aircraft velocity. Thus, there is a particular value of the ratio of aircraft velocity to height (the V/H ratio) which, at least directly beneath the aircraft, makes the scan lines contiguous one to the next, *i.e.* with no substantial overlap and no

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

This print takes account of replacement documents later filed to enable the application to comply with the formal requirements of the Patents Rules 1978.

unsurveyed gaps between the lines. For the equipment shown, the aircraft is flown so as to give a V/H ratio of one quarter the above-mentioned particular value, *i.e.* so that each scan line is contiguous with the fourth succeeding one. The relative positions of the filter/encoder disc 17 and the rotor 1, and the relative speeds thereof, are maintained such that each scan line is executed whilst a filter member lies between the ridge mirror 12 and the detector device 13. Successive scan lines are thus executed while respective successive ones of the four filter members are interposed between the mirror 12 and detector 13 and each line and the fourth successive line, which as mentioned are contiguous one to another, are executed while the same filter member is interposed.

The electrical signal produced by the detector 13 thus comprises a combination of four picture signals, these being representative of respective different radiation bandwidths from the same ground scene. Portions of the signal corresponding to the successive lines of the different pictures may be discriminated from one another and applied to say t.v. monitor equipment to display the four pictures as desired—for example the pictures may be displayed selectively (or simultaneously if more than one monitor is available) or may be combined as desired. The signal, in combined or discriminated form, might also be recorded by a video tape recorder say or (using suitable conversion apparatus) on film for subsequent discrimination, monitoring and/or analysis. Also, the monitoring and/or recording may be done on board the aircraft or the signal may simply be transmitted to appropriate ground-based equipment.

The filter/encoder disc 17 and the encoder disc 6 are used to provide synchronisation signals for use in the video signal processing apparatus (not shown) used for the monitoring and/or recording the signal from detector device 13, to provide signals for enabling the speeds of the scanning rotor drive motor and motor 15 to be synchronised, and to provide signals for denoting to which of the four different bandwidth pictures the successive lines of the signal from detector 13 belong. Thus, as shown in figure 3, the series of scanning rotor positions indicative signal pulses from the device 11 are fed to a phase-locked loop unit 30 which produces an output train of line synchronisation pulses, *i.e.* with a repetition rate of four times the speed of rotation of scanner rotor 1. As shown, in order to compensate for possible manufacturing inaccuracies in the assembly including the scanner rotor, in particular for any eccentricity of the scanner rotor, a plurality of electro-optical encoder devices, each like the device 11, may be arranged at spaced positions around the disc 17 to give respective pulse trains as the encoding holes in the disc move in and out of registers with the respective devices. In this case, the unit 30 is operable to produce an output sync pulse train on the basis of a combination of the input trains from the devices 11. The sync pulse train from unit 30 is fed to an appropriate frequency divider 31 to produce a frame synchronisation pulse train F, to output terminal L for application to the line synchronisation signal input of a video/sync mixer (not shown) and to one input of a phase-comparator unit 32, the other input of which is fed with a train of pulses formed by a sync pulse separator unit 33 and indicative of the speed and position of disc 17. The output from comparator 32 is fed *via* a filter/differentiation circuit 34 to a drive amplifier 35 controlling the speed of motor 15.

Since, in the illustrated case, the scanning rotor has four faces giving four scan lines for each revolution and since the disc 17 has four filter members, the speed of the disc 17 is made the same as that of the scanning rotor. Meanwhile, to identify the successive scan lines, *i.e.* to associate each line with a corresponding filter member, the holes in the periphery of the disc 17 comprise a single hole 40 at a first position, a pair of holes 41 closely spaced each side of a position 90° away from the first, a group of three closely spaced holes 41 diametrically opposite the hole 40 and a group of four holes 43 diametrically opposite the pair 41. The device 16 thus forms a single pulse signal to identify the first scan line of each sequence of four, two pulses to identify the second, three to identify the third and a group of four pulses to identify the fourth line. These pulses are fed to the separator unit 33 which uses them to form the signal applied to phase-comparator unit 32 and also outputs them at output I in a form suitable for use by the aforementioned video signal processing apparatus.

As will be appreciated, the disc 17 could comprise a number of filter discs other than four and the rotor 1 could have a number of reflective faces other than four—it would be triangular or hexagonal for example. The number of optical radiation bandwidths to be covered need not be the same as the number of filter members, for example the disc 17 could have two diametrically opposite filter members transparent to the same band and two interspersed members for a second band—the aircraft could then be flown with the V/H ratio such that each scan line is contiguous with the next but one. The relative rotation speed of the scanning rotor 1 and disc 17 is of course determined in dependence upon the particular arrangement chosen, *e.g.* the number of rotor faces and number of filter members. The speeds are not necessarily the same of course.

As with the disc 6, it may be desirable to provide several optical sender/receiver devices each like the device 16 around the periphery of disc 17. To assist say in d.c. restoration in the video signal processing apparatus it may be desirable to provide reference signal levels portions in each line of the signal from detector 13—this can be done by arranging a temperature-regulated member or vane so that radiation therefrom enters the detector for a short time during each scan line. This function could be performed by portion of disc 17.

It is not essential that the scanning rotor 1 and the filter disc 17 be driven by separate motors with electronic speed synchronisation therebetween. Instead, the disc 17 could be driven by the rotor drive motor, for example *via* a suitable toothed belt, gear or chain drive.

The references herein to values of V/H ratio at which the line-scanner bearing aircraft is flown do not of course have to be adhered to—it may be allowable for the scan lines to overlap on the ground or have gaps therebetween. Also, as will be appreciated, the line

scanner equipment will generally be controllable to operate with desired parameters — for example the scanning rotor speed may be selectable — and this may allow a range of V/H ratio to be used. Also, it is preferred that the scanner be constructed to allow relatively quick and easy in-field replacement of the filter disc 17. This would allow a disc with one filter configuration to be quickly replaced by one having say a different number of filters.

CLAIMS

1. Ground survey equipment comprising an optical radiation detector and scanner means for causing the detector to produce a video signal representative of a series of line scans over a ground scene, and further including filter carrier means supporting a plurality of filter members passing respective different optical radiation wavelength bands and drive means for causing the filter members to be moved in sequence into the path of the radiation received by the detector.

2. Equipment according to claim 1, wherein the filter carrier means is supported for rotation about an axis and said filter members are supported by the carrier means spaced around said axis, said drive means comprising a drive motor coupled to the filter carrier means to rotate it.

3. Equipment according to claim 1, including position encoder means coupled to said filter carrier means and operable for making available an electrical signal indicative of the positions of said filter members relative to said radiation path.

4. Equipment according to claim 1, wherein said scanner means comprises an opto-mechanical scanning mechanism including a rotatable reflective scanning rotor.

5. Equipment according to claim 4, wherein said scanning rotor and said filter members are coupled to respective electrical drive motors to be moved thereby and wherein the equipment includes speed control means connected to receive signals indicative of the speeds of the respective motors and operable to control the speed of one of the motors to maintain synchronism thereof with the other motor.

6. Ground survey equipment substantially as hereinbefore described with reference to the accompanying drawings.

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